PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04Q 7/32, 7/38

A1

(11) International Publication Number: **WO 97/30561**

(43) International Publication Date: 21 August 1997 (21.08.97)

(21) International Application Number: PCT/US97/02122

(22) International Filing Date: 10 February 1997 (10.02.97)

(30) Priority Data:
08/602,283 16 February 1996 (16.02.96) US

(71) Applicant: ERICSSON INC. [US/US]; 7001 Development Drive, P.O. Box 13969, Research Triangle Park, NC 27709 (US).

(72) Inventor: MÖLNE, Anders; 5148 Fairmead Circle, Raleigh, NC 27613 (US).

(74) Agents: GRUDZIECKI, Ronald, L. et al.; Burns, Doane, Swecker & Mathis, L.L.P., P.O. Box 1404, Alexandria, VA 22313-1404 (US).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published

With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: METHOD AND APPARATUS FOR ROAMING USING DUAL MODE/BAND EQUIPMENT INCLUDING SIM CARDS

(57) Abstract

According to exemplary embodiments of the present invention, mobile stations are provided with a preferred roaming selection list at a predetermined memory location in a subscriber identity module (SIM). The preferred roaming selection list identifies and prioritizes network operators to which that mobile station can be connected. Pointers are provided in the preferred roaming selection list to memory locations in the SIM where lists of networks associated with each entry in the list are stored. The memory locations are specified to be compatible with existing standards. The preferred roaming selection list can be modified over the air interface, e.g., via SMS class 2 messages, or by the user via the keypad of the mobile station.

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METHOD AND APPARATUS FOR ROAMING USING DUAL MODE/BAND EQUIPMENT INCLUDING SIM CARDS

BACKGROUND

The present invention relates generally to radio communications systems and, in particular, to techniques which allow mobile stations to roam in areas having overlapping radio communications systems in which different types of communication systems and/or different frequency bands provide alternative radio communication coverage.

The cellular telephone industry has made phenomenal strides in commercial operations in the United States as well as the rest of the world. Growth in major metropolitan areas has far exceeded expectations and is rapidly outstripping system capacity. If this trend continues, the effects of this industry's growth will soon reach even the smallest markets. Innovative solutions are required to meet these increasing capacity needs as well as maintain high quality service and avoid rising prices.

Throughout the world, one important step in the advancement of radio communication systems is the change from analog to digital transmission. Equally significant is the choice of an effective digital transmission scheme for implementing the next generation technology, e.g., time division multiple access (TDMA) or code division multiple access (CDMA). Furthermore, it is widely believed that the first generation of Personal Communication Networks (PCNs), employing low cost, pocket-sized, cordless telephones that can be carried comfortably and used to make or receive calls in the home, office, street, car, etc., will be provided by, for example, cellular carriers using the next generation digital cellular system infrastructure.

To provide an acceptable level of equipment compatibility, standards have been created in various regions of the world. For example, analog standards such as AMPS (Advanced Mobile Phone System), NMT (Nordic Mobile Telephone) and ETACS and digital standards such as D-AMPS (e.g., as specified

in EIA/TIA-IS-54-B and IS-136) and GSM (Global System for Mobile Communications adopted by ETSI) have been promulgated to standardize design criteria for radio communication systems. Once created, these standards tend to be reused in the same or similar form, to specify additional systems. For example, in addition to the original GSM system, there also exists the DCS1800 (specified by ETSI) and PCS1900 (specified by JTC in J-STD-007), both of which are based on GSM.

However, the most recent evolution in cellular communications services involves the adoption of additional frequency bands for use in handling mobile communications, e.g., for Personal Communication Services (PCS) services. Taking the U.S. as an example, the Cellular hyperband is assigned two frequency bands (commonly referred to as the A frequency band and the B frequency band) for carrying and controlling communications in the 800 MHz region. The PCS hyperband, on the other hand, is specified in the United States of America to include six different frequency bands (A, B, C, D, E and F) in the 1900 MHz region. Thus, eight frequency bands are now available in any given service area of the U.S. to facilitate communications services. Certain standards have been approved for the PCS hyperband (e.g., PCS1900 (J-STD-007), CDMA (IS-95) and D-AMPS (IS-136)), while others have been approved for the Cellular hyperband (e.g., AMPS (IS-54)).

Each one of the frequency bands specified for the Cellular and PCS hyperbands is allocated a plurality of voice or speech channels and at least one access or control channel. The control channel is used to control or supervise the operation of mobile stations by means of information transmitted to and received from the mobile stations. Such information may include incoming call signals, outgoing call signals, page signals, page response signals, location registration signals, voice channel assignments, maintenance instructions, hand-off, and cell selection or reselection instructions as a mobile station travels out of the radio coverage of one cell and into the radio coverage of another cell. The

control or voice channels may operate in either an analog mode, a digital mode, or a combination mode.

Historically, frequency bands in each cellular service area have been assigned to only one service company. For example, the A frequency band of the Cellular hyperband is usually reserved for use by non-wire line communications service companies, and the B frequency band is usually reserved for use by wire line communications service companies. Thus, if the service company providing cellular service to the subscriber is a wire line company, the Cellular hyperband mobile station is configured with the B frequency band as its "home" frequency band. Reciprocal billing arrangements between service companies allow subscribers to place calls over non-home frequency bands in the event the mobile station is roaming. These non-home calls, however, typically require payment by the subscriber of some form of a surcharge and are therefore undesirable. Furthermore, in the absence of an agreement between service companies, roaming subscribers may not be able to make a call without operator assistance. For the service provider, use of foreign frequency bands by subscribers results in a potential loss of revenue that the provider would like to avoid. Accordingly, cellular hyperband mobile stations have been configured to operate in a particular one of the available frequency bands within the Cellular hyperband.

The expansion to multiple hyperband communications capabilities as a result of the FCC's licensing of the PCS frequency bands has necessitated the development and placement into service of mobile stations that are capable of accessing both the Cellular and PCS hyperbands. To further complicate matters, different standards are being implemented in overlapping networks, e.g., an analog AMPS cellular base station on a first operator's network providing overlapping coverage with a PCS1900 base station connected to a second operator's network. Given this intermingling between standards and communication technologies, the number of different roaming permutations that must be addressed is significantly higher than those presented previously which,

for example, only raised the issue of which frequency band to select. Thus, it would be desirable to provide techniques for determining which of a plurality of different types of networks a mobile station should connect with as that mobile station moves between various different types of overlapping service areas. Further, unlike existing roaming solutions, flexibility in re-prioritizing roaming options (both by the subscriber's operator and the subscriber) is desired.

SUMMARY

According to exemplary embodiments of the present invention, mobile stations are provided with a preferred roaming selection list at a predetermined memory location in a subscriber identity module (SIM). The preferred roaming selection list identifies and prioritizes networks (operators) to which that mobile station can be connected, as well as keeping track of network operators to which a mobile station is barred access. For example, in a mobile station which is configured to communicate with either an AMPS type system or a PCS1900 type system, the preferred roaming selection list can include an identification of the home public land mobile network (home PLMN) associated with the PCS1900 system and the home system identification (SID) and the order in which the mobile station should select such operators. This stands in marked contrast to conventional AMPS mobile stations which do not store roaming information in a SIM and to conventional PCS1900 mobile stations which do not provide the flexibility to adjust roaming priorities. Preferred PLMNs and preferred SIDs which can also be utilized for communication services can also be identified and prioritized in the preferred roaming selection list in addition to the home networks.

Using the preferred roaming selection list, a mobile station can determine which of a plurality of different networks that are broadcasting in its current geographical area should be selected for connection. This facility can be used for cell selection, i.e., at power up of the mobile unit, or for cell reselection, i.e., when the mobile unit is roaming between cells belonging to different

networks. The mobile station can search for control channels having the identification codes stored at the pointed to locations in the SIM in the order of their priority as set forth in the preferred roaming selection list. In this way, the mobile station will connect with the highest ranked network in the list.

The preferred roaming selection list can be located at a predetermined memory location in the SIM so that this location is readily accessible to both operators and subscribers regardless of the type or manufacturer of the subscriber's operator or using any mobile station equipment. In this way, the selection priority as between both different networks and different systems can be easily changed. Similarly, the pointers used in the preferred roaming selection list can be specified for compatibility with existing SIM standards so that mobile stations operating in accordance with the present invention are also compatible with existing networks and systems and for ease of accessibility to update lists stored at the known memory locations.

The values stored in the preferred roaming selection list can be updated either over the air interface, e.g., by an operator, or by the user interfacing with the SIM via the keypad of the mobile station. For example, this can be accomplished by the operator using SMS class 2 messages.

An object of these various features of the present invention is to provide roaming data associated with any type of system which can be accessed, changed and updated by both the user and the operator (or by the operator on command from the user).

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing, and other, objects, features and advantages of the present invention will be more readily understood upon reading the following detailed description in conjunction with the drawings in which:

Figure 1 is a cell diagram illustrating an exemplary cell configuration for a multiple band/mode cellular communications system;

Figure 2 is a simplified block diagram of a multiple hyperband/mode mobile station programmable with hyperband and frequency band selection criteria in accordance with the present invention;

Figure 3 is a table illustrating a preferred roaming selection list according to an exemplary embodiment of the present invention; and

Figure 4 is an exemplary version of the preferred roaming selection list which can be stored in a SIM according to an exemplary embodiment of the present invention.

DETAILED DESCRIPTION

Prior to describing operation of mobile stations according to the present invention, a brief overview of conventional channel acquisition techniques (i.e., cell selection, handover and roaming) will first be described.

Consider first the simplest scenario wherein a mobile station only moves between areas serviced by a single AMPS operator. Then, when in the idle state, a mobile station tunes to and then continuously monitors the strongest control channel at its known frequency (generally, the control channel of the cell in which the mobile station is located at that moment) and may receive or initiate a telephone call through the corresponding base station. When moving between cells while in the idle state, the mobile station will eventually "lose" radio connection on the control channel of the "old" cell and tune to the control channel of the "new" cell. This process is commonly referred to as handover. The initial tuning to, and the change of, control channels are both accomplished automatically by scanning all the control channels at their known frequencies in operation in the cellular system to find the "best" control channel. When a control channel with good reception quality is found, the mobile station remains tuned to this channel until the quality deteriorates again. In this manner, all mobile stations are nearly always "in touch" with the system.

Conventional techniques have also been developed which allow a mobile station to roam between different operators in a single type of system. Consider, for example, a mobile station which roams between geographic areas covered by AMPS base stations operated by different service companies. Each service company broadcasts a unique system identification code (SID) on all paging channels of the frequency sets used to provide service by that service company in a given service area. This way, the mobile station can determine which service company is providing service on a given paging channel by identifying the SID. For example, a mobile station can select the strongest available control channel and determine the SID broadcast on the associated paging channel. If the broadcast SID is the same as the home SID which is stored in the handset, then that mobile station can be connected using the strongest control channel. Otherwise the mobile station will continue to search the control channels to which it can lock (i.e., which have a sufficiently high received signal strength) until the home SID is located or determined to be unavailable. If necessary, the mobile station can then revert to a preferred SID (PSID) if any are specified in the list. The PSID can, for example, be that associated with a service company that has a reciprocal agreement with the service company to which the mobile station has subscribed. If neither the home SID nor any of the preferred SIDS are available, then the AMPS mobile station might opt to lock onto a control channel associated with a preferred frequency band, i.e., the A band or the B band.

Note that the aforedescribed roaming techniques were hard coded into the AMPS mobile stations in a general memory area. This allowed for little or no flexibility in terms of changing either the order in which networks were selected while roaming or the identity of the networks which can be selected while roaming.

A similar solution has been adopted for the GSM standard, albeit at a slightly greater level of specificity. For example, in the PCS1900 network, which is based on GSM specification, the handset is typically preprogrammed,

e.g., by the operator storing data in a subscriber identify module (SIM) card, with information as to how that mobile station is to select the network. The SIM was created for GSM as a mechanism to conveniently group and store information elements related to the mobile subscriber.

For example, the identity (IMSI) of the home PLMN associated with a PCS1900 mobile station is stored at SIM memory location 6F07. Similarly, the identities of preferred PLMNs or forbidden PLMNs (if any) are stored at memory locations 6F30 and 6F7B, respectively. These and other attributes of subscriber identity modules are standardized for GSM specified mobile stations in the document entitled "Specification of the Subscriber Identity Module-Mobile Equipment (SIM-ME) Interface", GSM 11.11, Version 4.10.0, dated January 21, 1994, the disclosure of which is incorporated here by reference.

In the PLMN selection process, which is also hard coded into the PCS1900 mobile station like that of AMPS, the mobile station normally looks for cells only in its home PLMN. If no service is available on the home PLMN, then the mobile station will search for a preferred PLMN whose identities are stored at SIM memory location 6F30. If the mobile station locks onto a preferred PLMN, the user can alternatively select another network by commanding the mobile station to make a new network search, assuming that there is a second network covering the geographic area in which the mobile station is currently located which is not identified as a forbidden PLMN at SIM memory location 6F7B. These forbidden PLMNs may be identified by the subscriber's network operator so that the mobile station will not access these other networks (except in the case of emergency 911 calls).

Although the conventional solutions described above are adequate for geographic areas in which only a single type of system is operating or for mobile stations which are only capable of listening to a single type of system, those skilled in the art will appreciate that the evolution of communication systems will gradually render these situations less common and make more frequent the situations where a multi-system capable mobile station will travel through areas

serviced by multiple different types of networks. Moreover, the hard-coded priority selection function provided in these conventional mobile stations does not provide the user or the network operator with sufficient flexibility to adjust selection priorities among the many different network operators which will provide alternative service in the communication world of today and beyond. Reference is now made to Figure 1 wherein there is shown a cell diagram illustrating an exemplary cell configuration having different networks and network operators in which mobile stations and roaming techniques according to the present invention provide numerous beneficial results.

Therein, an arbitrary geographic area is divided into a plurality of cells 10-18 controlled by a first operator or service company and cells 20-26 controlled by a second operator or service company. The first and second operators provide radio communication services utilizing first and second communication standards, respectively. For example, cells 10-18 are represented by hexagrams and comprise communications cells wherein communications are provided via multiple channels according to PCS1900 and using a PCS frequency band. Cells 20-26, on the other hand, are represented by circles and comprise communications cells in which cellular communications are provided to mobile stations via multiple channels according to the AMPS standard in the cellular hyperband.

Each of the PCS1900 operated cells 10-18 includes at least one base station 28 configured to facilitate communications over certain channels in at least one of the six available PCS hyperband frequency bands. Similarly, each of the AMPS operated cells 20-26 includes at least one AMPS base station 30 configured to facilitate communications over certain channels in at least one of the two available AMPS frequency bands. It will, of course, be understood that each cell 10-18 and each cell 20-26 may include more than one base station 28 and 30, respectively, if for example, different service companies are providing cellular communications services on different frequency bands within the same cell.

The base stations 28 and 30 are illustrated as being positionally located at or near the center of each of the cells 10-18 and 20-26, respectively. However, depending on geography and other known factors, either or both of the base stations 28 and 30 may instead be located at or near the periphery of, or otherwise away from the centers of, each of the cells 10-18 and 20-26. In such instances, the base stations 28 and 30 may broadcast and communicate with mobile stations 32 located within the cells 10-18 and 20-26 using directional rather than omni-directional antennas. Each one of the base stations 28 and 30 includes a plurality of transceivers connected to one or more antennas in a manner and with a configuration well known in the art.

There are a number of mobile stations 32 shown operating within the service areas illustrated in Figure 1. These mobile stations 32 each possess the requisite functionality for operating in both the cellular frequency bands and the PCS frequency bands (i.e., they are multiple hyperband communications capable) and are capable of operating in different modes, e.g., analog or digital modulation, according to AMPS or PCS1900, etc. The configuration and operation of the mobile stations 32 will be described in more detail herein with respect to Figure 2.

Reference is now made to Figure 2 wherein there is shown a simplified block diagram of a multiple hyperband, multiple mode mobile station 32 according to an exemplary embodiment of the present invention. The mobile station 32 includes a processor (CPU) 34 connected to a plurality of transceivers 36. The transceivers 36 are each configured to operate in the frequency bands and channels of a different hyperband. For example, the transceiver 36(1) functions on multiple channels in at least one of the frequency bands of the 800 MHz frequency range, and is thus utilized by the mobile station 32 for communicating over the cellular hyperband. The transceiver 36(2), on the other hand, functions on multiple channels in at least one of the frequency bands of the 1900 MHz frequency range, and is thus utilized by the mobile station 32 for communicating over the PCS hyperband. The remaining transceivers 36(3) and

36(4), if included, function in other frequency ranges; for example, comprising those additional frequency ranges identified by the FCC for other soon to be made available hyperbands. Those skilled in the art will appreciate that an exemplary embodiment of the present invention can include only transceivers 36(1) and 36(2) to reduce the cost of the unit. Alternatively, it may be possible to use one transceiver capable of operating in either band, e.g., 800 MHz or 1900 MHz. By means of an output signal from the processor 34, the frequency band and precise channel therein on which the transceivers 36 operate for communications may be selected. Additionally, each transceiver can be adapted as a dual mode analog/digital transceiver. Such devices are described, for example, in U.S. Patent Application Serial No. 07/967,027, entitled "Multi-Mode Signal Processing" to Paul W. Dent et al and filed on October 27, 1992, the disclosure of which is incorporated here by reference. In this way, each of the mobile stations 32 can communicate with different types of networks which it may encounter while roaming, e.g., PCS1900 and AMPS.

An antenna 38 is connected to the transceivers 36 for transmitting and receiving radio communications (both voice and data) over the cellular communications network utilizing, for example, the base stations 28 and 30 of Figure 1. A data storage device 40 (preferably in the form of a read only memory - ROM - and a random access memory - RAM) is also connected to the processor 34. The data storage device 40 is used for storing programs and data executed by the processor 34 in controlling operation of the mobile station 32. Another memory device 41, commonly referred to as a subscriber identity module (SIM) is also connected to CPU 34, the functionality of which is described below. There are other components 42 included in the mobile station 32 (like a handset, keypad, etc.) and not specifically shown in Figure 2 whose nature, operation and interconnection with the illustrated components are well known to those skilled in the art.

Of particular interest herein is the operation of mobile stations as described above when roaming among geographic areas which include the service

areas of many different types of radio communication systems. For example, the manner in which the mobile station 32 will select between a PLMN supported by base station 28 in cell 16 and the AMPS operator supported by base stations 30. The more network operators that are added to the scenario, the more complicated

09/980719

5000

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 March 2002 (14.03.2002)

PCT

(10) International Publication Number
WO 02/21861 A2

(51) International Patent Classification[7]: H04Q 7/00

(21) International Application Number: PCT/IB01/01867

(22) International Filing Date:
11 September 2001 (11.09.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0022205.9 11 September 2000 (11.09.2000) GB

(71) Applicant *(for all designated States except US)*: **HONG KONG CSL LIMITED** [CN/CN]; 8/F Oxford House, Taikoo Place, 979 King's Road, Quarry Bay, Hong Kong (CN).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **LEUNG, Edward, Yan, Tao** [CN/CN]; Flat 27c, Tower 1, Well On Garden, Tseung Kwan O, Hong Kong (CN). **MIDGETT, Richard** [US/CN]; c/o Hong Kong CSL Ltd, 8/F Oxford House, Taikoo Place, 979 King's Road, Quarry Bay, Hong Kong (CN). **YAU, Kwok, Wing** [CN/CN]; c/o Hong Kong CSL Ltd, 8/F Oxford House, Taikoo Place, 979 King's Road, Quarry Bay, Hong Kong (CN).

(74) Agent: **MEILMAN, Edward, A.**; Dickstein Shapiro Morin & Oshinsky LLP, 1177 Avenue of the Americas, New York, NY 10036 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 02/21861 A2

(54) Title: MOBILE COMMUNICATIONS

(57) Abstract: A method of automatically establishing a roaming service for a mobile telephone, that includes a pre-programmed SIM card, performs a Location Update in the following order. 1. Registered Public Land Mobile Network ("RPLMN"), i.e. the last registered network as stored in the SIM directory EF_{LOCI} (EF6F7E). 2. Home PLMN ("HPLMN"). 3. PLMNs contained in a "PLMN Selector" data field based on the "Operator List". 4. User - defined preferred PLMN. 5. Other PLMNs with received signal level above a predetermined strength in random order; and 6. All other PLMNs in order of descending signal strength.

MOBILE COMMUNICATIONS

The invention relates to mobile communications.

Global System for Mobile Communications ("GSM") is a technology widely adopted by mobile equipment operators throughout the world. To facilitate GSM automatic international roaming service, a set of guidelines exists so that when two GSM network operators wish to establish a roaming service, they have to establish a bilateral roaming agreement, followed by the technical and billing tests. With an automatic roaming service, mobile users do not need to change the Mobile Equipment ("ME") and the Subscriber Identity Module ("SIM"). Mobile users can make and receive calls in a visited network as if they are in a home network by using the roaming service.

Before a mobile user can use a mobile service in a visited network, the mobile user has to successfully register with the mobile service in the visited network. The procedure is called Location Update. If the home network has established a roaming service with more than one mobile operator in a same visited region, mobile users can either manually select one of the operators in the visited region, or use an auto-selection mode to perform the Location Update. According to the GSM Technical Specification 02.11, the Mobile Station ("MS")

which is comprised of ME and SIM shall perform the Location Update in the following order when the auto-selection mode is used:

1. Registered Public Land Mobile Network ("RPLMN"), i.e. the last registered network as stored in the SIM directory EF_{LOCI} (EF6F7E)

2. Home PLMN ("HPLMN")

3. PLMNs contained in the "PLMN Selector" (EF6F30) data field in the SIM (in priority order);

4. Other PLMNs with received signal level above a pre-determined value specified in the GSM specification in random order;

5. All other PLMNs in order of descending signal strength

In this order, only the "PLMN Selector" (EF6F30) will allow users to enter the preferred roaming networks. According to the GSM Technical Specification 11.11, this list is readable and can be updated by mobile users through ME.

With the introduction of Inter-Operator Tariff (IOT) by the GSM Association, network operators can negotiate with their roaming partners for a more flexible tariff. In addition, there is an increasing demand from customers for auto-selecting a better quality roaming network, and the need to prevent preferred network from

writing onto the Forbidden PLMN (FPLMN) list as a result of transient signaling fault, unsuccessful Location Update in previous registration and so on. This follows that one roaming network operator is preferred to another, based on service quality, customer services and commercial consideration. However, the existing procedure does not provide network operators with any flexibility to control the order of mobile networks in the Location Update procedure.

It is an object of the invention to enable a network operator to derive a mechanism to ensure a preferred roaming network is selected with a chosen or flexible priority.

According to a first aspect of the invention there is provided a mobile telephone arranged to automatically re-establish roaming service with a network based on an "Operator List" by modifying the Registered Public Land Mobile Network ("RPLMN") during Location Update, through the use of a pre-programmed SIM card

According to a second aspect of the invention, there is provided a method of automatically establishing a roaming service for a mobile telephone, including using a pre-programmed SIM card such that the preferred networks are selected in preference to others. Subsequently, although the Location Update is performed

in the same order as before, the networks list being accessed is modified and the mechanism is described as follows:-

1. Registered Public Land Mobile Network ("RPLMN"), i.e. the last registered network as stored in the SIM directory EF_{LOCI} (EF6F7E).
2. Home PLMN ("HPLMN");
3. PLMN contained in a "PLMN Selector" data field based on the "Operator List"
4. User-defined preferred PLMN;
5. Other PLMNs with received signal level above a pre-determined strength in random order; and
All other PLMNs in order of descending signal strength.

In an embodiment of the invention an "Operator List" with preferred roaming networks set by the home network operator is created and built into the SIM. This list can be updated by the home network operator by means of data download over the air. Examples of updating the home network operator are as follows:-

- Over the air: Normal Short Message Services ("SMS")
- Over the air: SIM Application Toolkit ("SAT") data download by SMS
- Over the air: data download by Unstructured Supplementary Service Data ("USSD")
- Over the air: SAT data download by Wireless Application Protocol ("WAP")

- Using SIM editor at services centers/shops
- Making use of Mobile Station Application Execution Environment ("MExE") platform between SIM application and Services Server application, download operator list data by the common circuit switch bearers (e.g. circuit switch 9.6kbps data) and packet switch bearers (e.g. packet switch based General Packet Radio Service ("GPRS") data)

During Location Update in auto-selection mode, MS will compare the RPLMN with the "Operator List". If the Mobile Country Code ("MCC") of the RPLMN is found in the "Operator List", the first available preferred network with the same MCC will replace that in RPLMN so that the MS searches and attempts to register to this network.

In addition, the "Operator List" will be copied to the PLMN Selector (EF6F30) and referenced by the MS during Location Update. The copying of "Operator List" over PLMN Selector (EF6F30) can be a direct copy or replaced by an indexed pre-stored list. If mobile users have entered preferred networks in PLMN Selector (EF6F30), the user-defined networks will be appended at the end, provided that there is free entry available. Thus, in auto-selection mode, the normal order of selection is unchanged, but the content of the network list is modified. As a result, the process is changed to:-

1. Registered Public Land Mobile Network

("RPLMN") with reference to "Operator List";

2. Home PLMN ("HPLMN");

3. PLMN as listed in the "Operator List" in the PLMN selector (EF6F30). The entries of the "Operator list" are stored in a specific location on the SIM e.g. EF6D30;

4. User-defined preferred PLMNs in the PLMN Selector (EF6F30). These user-defined preferred PLMNs have lower priority than those PLMNs of the "Operator List" in the PLMN Selector (EF6F30)as they are appended after the "Operator List"

5. Other PLMNs with received signal level above a pre-determined value specified in the GSM specification in random order; and

6. All other PLMNs in order of descending signal strength

Manual selection mode by the user is not affected. Mobile users can still override the auto-selection by selecting a particular network manually. A new capability can be provided to allow the home network operator flexibility to restore partly or wholly the order of Location Update procedure through data download over the air.

A roaming service for mobile operators according to the invention will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 illustrates a data structure of the "Operator List";

Figure 2 illustrates a flow at the initial power on stage;

Figure 3 illustrates an EF_{LOCI} Update Enhancement;

Figure 4 illustrates the mechanism of Over The Air ("OTA") data download; and

Figure 5 illustrates the mechanism to handle the OTA data download in a SIM card.

A new list "Operator List" is created and built in the Elementary File ("EF") in a SIM. The address of the "Operator List" is arbitrary and defined by a home operator in SIM production. In this example, the address EF6D30 is used. Figure 1 shows the data structure of this "Operator List". The size, X, of the "Operator List" can be varied. However, it must be the same as a PLMN Selector (EF6F30). According to a GSM Technical Specification, EF6F30 must contain at least 8 network entries in the format of MCC and Mobile Network Code ("MNC"). For each network entry, it will take up 3 bytes. Therefore, the minimum size of the EF6D30 is 26 bytes including the header bytes F and V. It is however

recommended to have a maximum of X less than 255 bytes since each file transfer from SIM to ME is in steps of 255 bytes for EF type. The header byte V indicates the number of valid network entries in the "Operator List". The header byte F is a flag with 4 possible values: If "F"=0, OTA update is not performed. (See Figure 4 for further explanation). Mask to Mask comparison (See Figure 2 for further explanation) between "Operator List" (EF6D30) and PLMN Selector (EF6F30) is required at power on stage. Examples of other comparison methods are as follows :

- Mask to Mask comparison between the "Operator List" (EF6D30) and the PLMN Selector (EF6F30) and the "Operator List" has higher priority than the user-defined PLMNs. The user-defined PLMNs are then appended at the end of the "Operator List" when copying onto PLMN Selector (EF6F30), provided that there is available memory spaces in the PLMN Selector (EF6F30).
- Entry to Entry comparison between the "Operator List" (EF6D30) and the PLMN Selector (EF6F30) and the "Operator List" has higher priority than the user-defined PLMNs. In this case, the redundant entries are eliminated
- Entry to Entry comparison between the "Operator List" (EF6D30) and the PLMN Selector (EF6F30). Any redundant entries are eliminated. The priorities of the entries are determined by analyzing the history of

individual roaming behaviour. This is to maximise the opportunity for ME to take an entry into usage, assuming that the mobile equipment is able to process entries in EF6F30 up to a certain limited length.

If "F"=1, OTA data download has been performed. At power on stage, when ME performs a Read binary on EF6F30, no Mask to Mask comparison between EF6D30 and EF6F30 is required. If "F"=2, only the EF_{LOCI} Update Enhancement (See Figure 3 for further explanation) is performed. If "F"=3, the enhancements mentioned in this description will be disabled and the normal order of Location Update is performed.

Figure 2 illustrates the sequence at the initial power on stage. The value F in EF6D30 is checked at the power on stage. If "F"=0, a Mask to Mask comparison between EF6D30, which has "V" valid network entries, and the first "V" entries of EF6F30 is performed. The resulting difference, i.e. network entries in EF6F30 that are not mapped in Mask to Mask comparison are identified. Afterwards, the content of "Operator List" (EF6D30) is copied onto EF6F30, followed by the difference. When searching for preferred networks, the ME is based on the new preferred networks in EF6F30 and the operator defined networks will be searched first.

Any subsequent update on the PLMN Selector (EF6F30) by

mobile users through Man Machine Interface ("MMI") is written on the EF6F30 as in a normal operation. However, the update only lasts for the session the MS is on. In the next power on, the Mask to Mask comparison is performed as described earlier. The resulting different network entries are then appended after the "Operator List" to PLMN Selector (EF6F30). Thus, the PLMN Selector (EF6F30) in ME's memory becomes the "Operator List" followed by user defined list immediately after power on. Examples of the triggering method include the following:-

- Power ON-OFF to trigger the LOCI and PLMN enhancement (the current implementation)
- 1st reading attempt on Location Information ("LOCI") after power reset on SIM triggers the LOCI enhancement
- 1st reading attempt on EF6F30 after power reset on SIM triggers the PLMN enhancement
- Any time when the SAT detects a change of MCC of RPLMN (i.e. roaming in other countries) and a subsequent re-read of EF6F30 is issued to the mobile equipment

Figure 3 illustrates the EF_{LOCI} Update Enhancement. In accordance with the GSM Technical Specification, the Registered Network (RPLMN) as listed in EF_{LOCI} is searched first in auto-selection mode. After the Mask to Mask comparison, EF_{LOCI} is checked against the Operator List (EF6D30). If the current value of EF_{LOCI} is already in

EF6D30, no modification on the EF_{LOCI} is required. Otherwise, the MCC of EF_{LOCI} is checked against that in EF6D30. If there is a match, the MNC of the first matched network in EF6D30 replaces the MNC in EF_{LOCI}. In addition, the value in EF_{BCCH} is reset. The ME is based on the modified EF_{LOCI} to search for the Registered Network (RPLMN).

Figure 4 illustrates the mechanism of OTA data download. A home network operator can update the "Operator List" by means of short message data download. The list of roaming operators in the format of MCC and MNC forms a short message content. The header bytes "NumOfEntry" and "Algorithm" indicates the number of preferred network entries and the choice of algorithm to be used. There are three possible algorithms:-

1. The operator-defined preferred roaming networks and the EF_{LOCI} update enhancement is used;
2. Only the EF_{LOCI} update enhancement is used; and
3. Neither the operator-defined preferred roaming network nor the EF_{LOCI} update enhancement is used, i.e. the original order of Location Update procedure is recovered.

In addition, due to the possible size limitation of the short message, more than 1 short message may be used in the data download. Thus, a byte is used to indicate the

session number for the data download in the short message. To avoid hacking, security measures are implemented. The Transfer Layer Protocol-Originating-Address ("TO-OA") used to send the short message must be matched with one defined in the SIM during production stage. In addition, the content of the short message, excluding the "NumOfEntry" byte and "Algorithm" byte are calculated for checksum. A simple approach is to sum the Exclusive OR ("XOR") results of two bytes pair. Other examples of possible security enhancements include:-

Content check sum plus checking of TP-OA

- Check sum algorithm based on Ki (the secret key shared between the SIM and the network) of the SIM or International Mobile Subscriber Identity ("IMSI") of the SIM

- Interactive authentication via call or supplementary services ("SS") or SMS by SAT application

Figure 5 illustrates the mechanism to handle the OTA data download in a SIM card. The short message received via OTA download triggers the resident script built in SIM card to update the flag to F=1, and the content of EF6D30 is then updated accordingly. An acknowledgement short message will be sent back to a pre-defined address. Upon the next power up, a step translation will be performed in EF6F30 to offset the user defined network list to a correct offset so that the user

defined network list is not overwritten in the case that the updated "Operator List" is longer than previous one. On the other hand, if the new "Operator List" is shorter than the previous one, the difference is removed. Then the new content of EF6D30 is copied to EF6F30 and placed before the user defined network list. The flag "F" is then reset to 0.

Embodiments enable automatic selection of the technically and quality-wise best network available for the user. The selection can also be automatically "biased" to enable the cheapest available network for each user according to users' or mobile services provider's specific commercial arrangement. A services provider is also able to remotely assist a roaming customer by up-dates transmitted to alter data in the SIM card. Normally only 8 to 16 entries are available and so a user-defined or operator defined short list of networks can be sent actively to the user depending upon the mobile telephone customers geographical habits.

Enhancements of the described roaming service can include the following:-

- Network entries which are in the operator list are removed from a Forbidden list after the triggering "after power ON/OFF"
- Operator list based on Location Update Message

received from the foreign (visited) network from our individual customers is optimised to avoid the mobile equipment limited ability in handling long PLMN selectors (EF6F30).

CLAIMS

1. A mobile telephone arranged to automatically re-establish roaming service with a network based on an "Operator List" by modifying the Registered Public Land Mobile Network ("RPLMN") during Location Update, through the use of a pre-programmed SIM card

2. A method of automatically establishing a roaming service for a mobile telephone, including using a pre-programmed SIM card such that a Location Update is performed in the following logical order:-

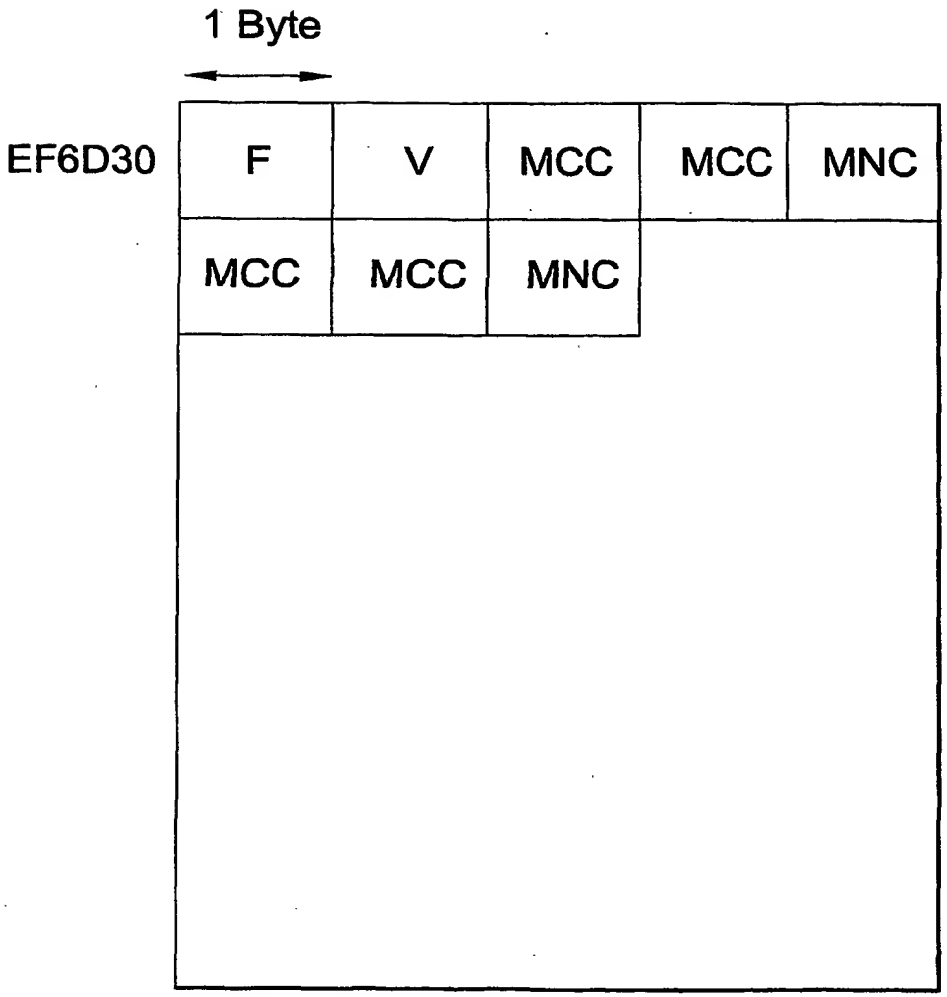
1. Registered Public Land Mobile Network ("RPLMN"), i.e. the last registered network as stored in the SIM directory EF_{LOCI} (EF6F7E)
2. Home PLMN ("HPLMN")
3. PLMNs contained in a "PLMN Selector" data field based on the "Operator List".
4. User - defined preferred PLMN
5. Other PLMNs with received signal level above a predetermined strength in random order; and
6. All other PLMNs in order of descending signal strength

3. A method according to Claim 2 in which the PLMN is stored in the "Operator List" reserved in a fixed but implementation-dependent memory location in the SIM,

e.g. EF6D30.

4. A method according to Claim 2 or 3, in which the "PLMN Selector" data comprises PLMN's listed in the "Operator List" copied on to the "PLMN Selector", the "Operator List" taking precedence over user - defined preferred PLMN's which are appended at the end of the "Operator List" in the "PLMN Selector".

5. A method according to any one of claims 2 to 4 wherein during network selection the country code of the RPLMN is compared with networks defined in the "Operator List" the most preferred network with the country code replacing the RPLMN.



File Size = X bytes
V = No of valid network entries
F = Flag

Fig. 1

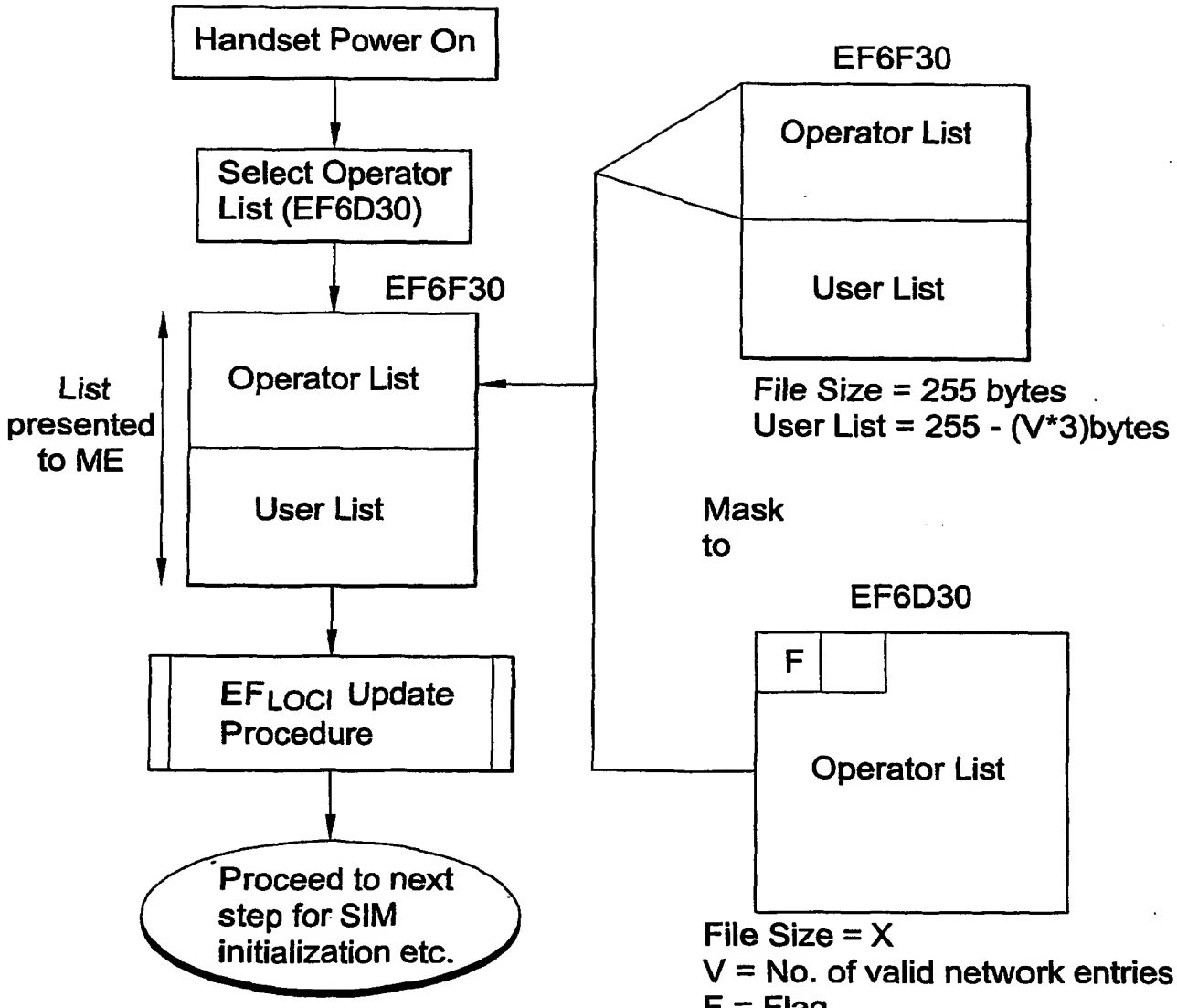

Handset Power On
Select Operator List (EF6D30)
EF6F30
Operator List
User List
List presented to ME
EF6F30
Operator List
User List
File Size = 255 bytes
User List = 255 - (V*3)bytes
Mask to
EF6D30
F
Operator List
EFLOCI Update Procedure
Proceed to next step for SIM initialization etc.
File Size = X
V = No. of valid network entries
F = Flag

Fig. 2

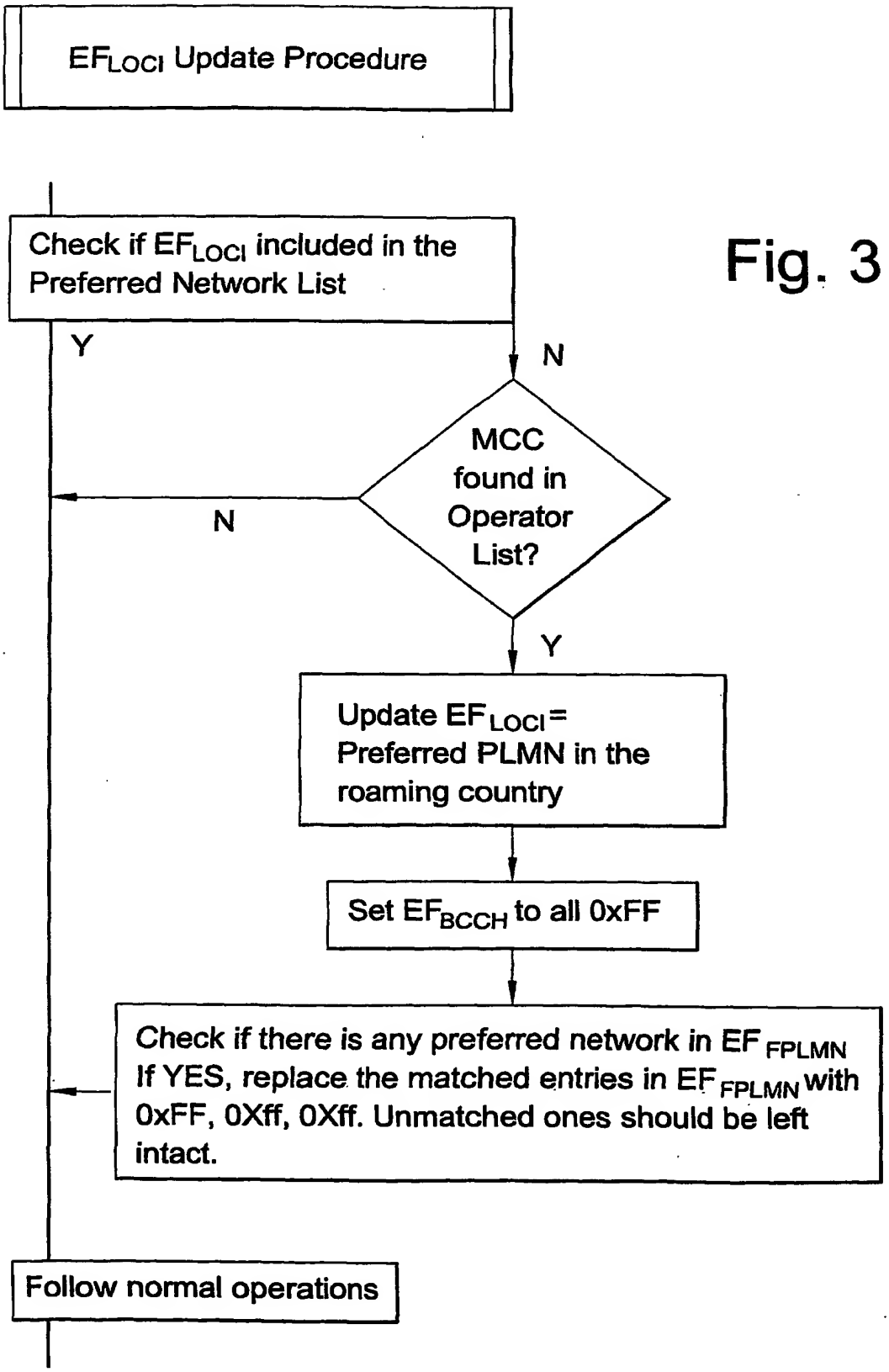

EF$_{LOCI}$ Update Procedure
Check if EF$_{LOCI}$ included in the Preferred Network List
Y
N
MCC found in Operator List?
N
Y
Update EF$_{LOCI}$ = Preferred PLMN in the roaming country
Set EF$_{BCCH}$ to all 0xFF
Check if there is any preferred network in EF$_{FPLMN}$ If YES, replace the matched entries in EF$_{FPLMN}$ with 0xFF, 0Xff, 0Xff. Unmatched ones should be left intact.
Follow normal operations

Fig. 3

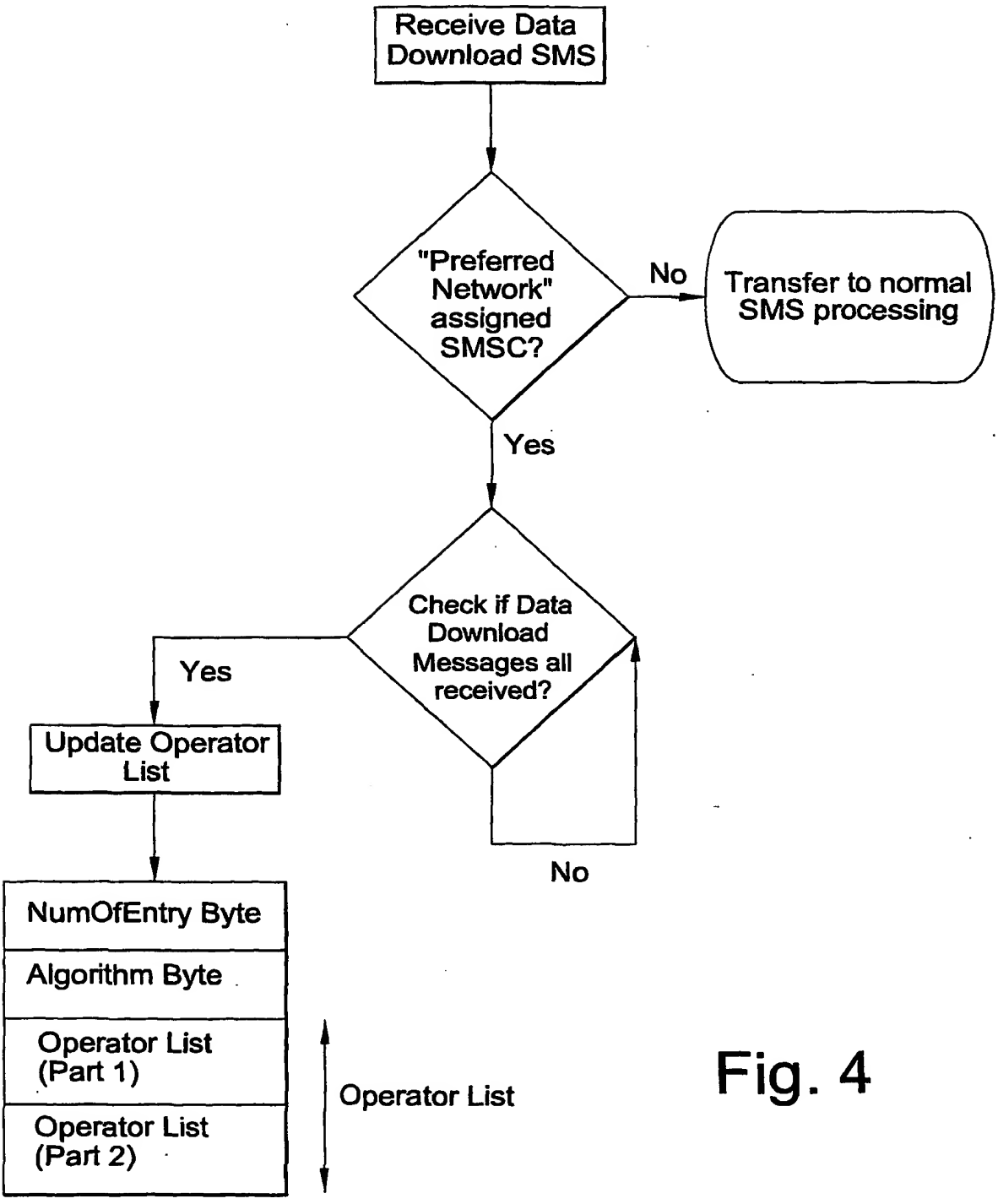
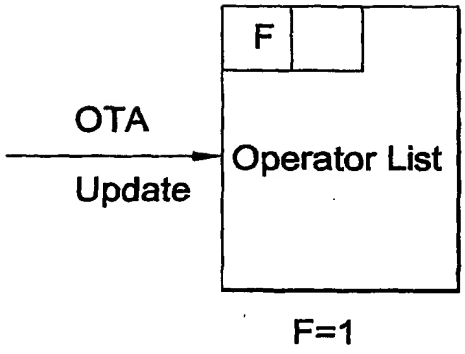

Receive Data Download SMS
"Preferred Network" assigned SMSC?
No
Transfer to normal SMS processing
Yes
Check if Data Download Messages all received?
Yes
No
Update Operator List
NumOfEntry Byte
Algorithm Byte
Operator List (Part 1)
Operator List (Part 2)
Operator List

Fig. 4


F
OTA
Update
Operator List
F=1

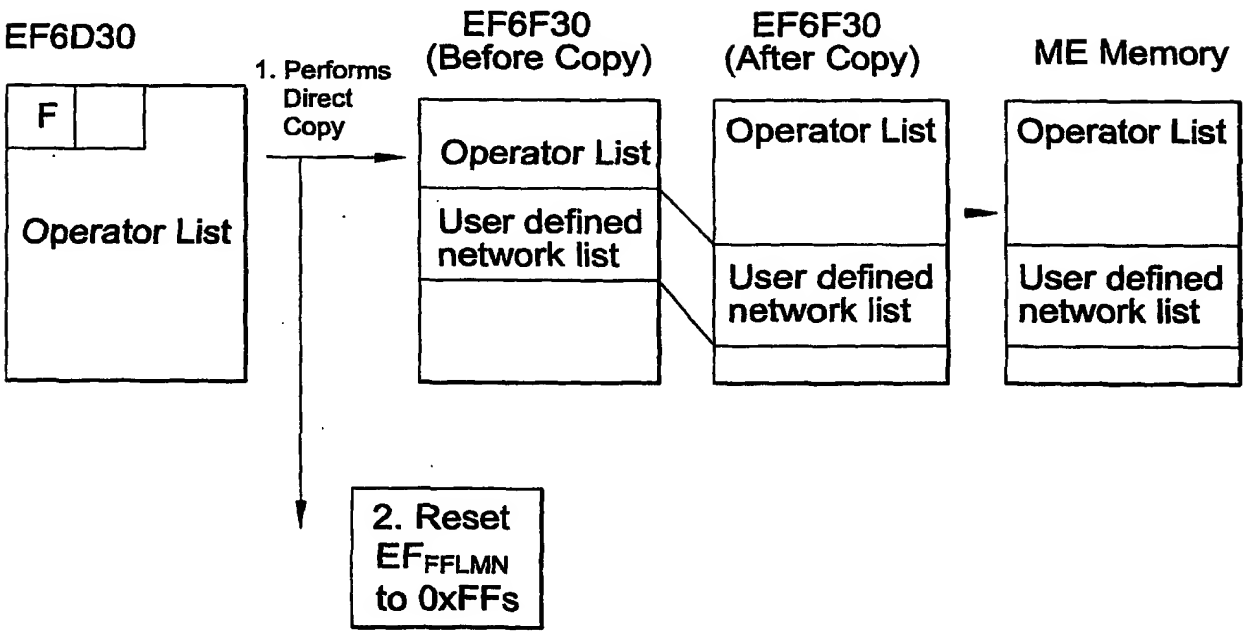

At the Next Power On after the OTA Update
EF6D30
F
Operator List
1. Performs Direct Copy
EF6F30 (Before Copy)
Operator List
User defined network list
EF6F30 (After Copy)
Operator List
User defined network list
ME Memory
Operator List
User defined network list
2. Reset EFFFLMN to 0xFFs

Fig. 5

09-80-949

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 March 2002 (14.03.2002)

PCT

(10) International Publication Number
WO 02/21861 A3

(51) International Patent Classification[7]: H04Q 7/32

(21) International Application Number: PCT/IB01/01867

(22) International Filing Date:
11 September 2001 (11.09.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0022205.9 11 September 2000 (11.09.2000) GB

(71) Applicant *(for all designated States except US)*: **HONG KONG CSL LIMITED** [CN/CN]; 8/F Oxford House, Taikoo Place, 979 King's Road, Quarry Bay, Hong Kong (CN).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **LEUNG, Edward, Yan, Tao** [CN/CN]; Flat 27c, Tower 1, Well On Garden, Tseung Kwan O, Hong Kong (CN). **MIDGETT, Richard** [US/CN]; c/o Hong Kong CSL Ltd, 8/F Oxford House, Taikoo Place, 979 King's Road, Quarry Bay, Hong Kong (CN). **YAU, Kwok, Wing** [CN/CN]; c/o Hong Kong CSL Ltd, 8/F Oxford House, Taikoo Place, 979 King's Road, Quarry Bay, Hong Kong (CN).

(74) Agent: **MEILMAN, Edward, A.**; Dickstein Shapiro Morin & Oshinsky LLP, 1177 Avenue of the Americas, New York, NY 10036 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

(88) Date of publication of the international search report:
16 May 2002

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 02/21861 A3

(54) Title: ROAMING SERVICE FOR MOBILE COMMUNICATIONS

(57) Abstract: A method of automatically establishing a roaming service for a mobile telephone, that includes a pre-programmed SIM card, performs a Location Update in the following order. 1. Registered Public Land Mobile Network ("RPLMN"), i.e. the last registered network as stored in the SIM directory EF_{LOCI} (EF6F7E). 2. Home PLMN ("HPLMN"). 3. PLMNs contained in a "PLMN Selector" data field based on the "Operator List". 4. User - defined preferred PLMN. 5. Other PLMNs with received signal level above a predetermined strength in random order; and 6. All other PLMNs in order of descending signal strength.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 01/01867

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 781 064 A (NOKIA MOBILE PHONES LTD) 25 June 1997 (1997-06-25) column 4, line 52 -column 5, line 10 column 6, line 6 - line 8 column 12, line 49 - line 52 column 14, line 27	1,2,5
E	FR 2 808 645 A (FRANCE TELECOM) 9 November 2001 (2001-11-09) the whole document	1
X	WO 99 40746 A (QUALCOMM INC) 12 August 1999 (1999-08-12) page 8, line 5 - line 7	1

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 February 2002	27/02/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Leouffre, M

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	ETSI: "Digital cellular telecommunications system (Phase 2+);Specification of the Subscriber Identity Module - Mobile Equipment (SIM - ME) interface (GSM 11.11 version 6.2.0 Release 1997)" TS 100977 V6.2.0, XX, XX, May 1999 (1999-05), XP002158150 cited in the application the whole document	1

IN ERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IB 01/01867

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP 0781064	A	25-06-1997	US	5903832 A	11-05-1999
			EP	0781064 A2	25-06-1997
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			WO	9940746 A1	12-08-1999

09980949

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 March 2002 (14.03.2002)

PCT

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WO 02/021861 A3

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(25) Filing Language: English

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(74) Agent: **MEILMAN, Edward, A.**; Dickstein Shapiro Morin & Oshinsky LLP, 1177 Avenue of the Americas, New York, NY 10036 (US).

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(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *with amended claims*

(88) Date of publication of the international search report:
16 May 2002

Date of publication of the amended claims: 18 July 2002

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 02/021861 A3

(54) Title: ROAMING SERVICE FOR MOBILE COMMUNICATIONS

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AMENDED CLAIMS

[received by the International Bureau on 2 April 2002 (02.04.02);
original claims 1-5 replaced by amended claims 1-11 (5 pages)]

1. A mobile telephone arranged to automatically re-establish roaming service with a network based on an "Operator List" by modifying the Registered Public Land Mobile Network ("RPLMN") during location update procedure, through the use of a pre-programmed Subscriber Identity Module ("SIM") card.

2. A mobile telephone according to claim 1 wherein during location update procedure at power on of the mobile telephone a country code of the RPLMN is compared with networks defined in the "Operator List", the most preferred network with the same country code replacing the RPLMN.

3. A method of automatically establishing a roaming service for a mobile telephone, including using a pre-programmed Subscriber Identity Module ("SIM") card such that a network updated procedure is performed in the following logical order:-

1. Registered Public Land Mobile Network ("RPLMN"),

2. Home Public Land Mobile Network ("HPLMN"),

3. Public Land Mobile Networks ("PLMNs") contained in a "PLMN Selector" data field based on an "Operator List",

4. User-defined preferred PLMN,

5. Other PLMNs with received signal level above a predetermined strength in random order, and

6. All other PLMNs in order of descending signal strength.

4. A method according to Claim 3 in which the PLMN is stored in the "Operator List" reserved in a fixed but implementation-dependent memory location in the Subscriber Identity Module.

5. A method according to Claim 3 or 4, in which the "PLMN Selector" data comprises PLMNs listed in the "Operator List" copied on to the

"PLMN Selector", the "Operator List" taking precedence over user-defined preferred PLMNs which are appended at the end of the "Operator List" in the "PLMN Selector".

6. A method of automatically establishing a roaming service for a mobile telephone wherein during a network update procedure Public Land Mobile Networks ("PLMNs") contained in a "PLMN Selector" data field based on an "Operator List" have preference over other User-defined or Operator-defined preferred PLMNs.

7. A Subscriber Identity Module, for a mobile telephone, pre-programmed to, at power on of the mobile telephone, automatically re-establish roaming service with a network based on an "Operator List" by modifying the Registered Public Land Mobile Network ("RPLMN") during a location update procedure, wherein a country code of the RPLMN is compared with networks defined in the "Operator List", the

most preferred network with the same country code replacing the RPLMN.

8. A Subscriber Identity Module for a mobile telephone pre-programmed, to, in use, perform network update procedure in the following logical order:-

1. Registered Public Land Mobile Network ("RPLMN"),

2. Home Public Land Mobile Network ("HPLMN"),

3. Public Land Mobile Networks ("PLMNs") contained in a "PLMN Selector" data field based on an "Operator List",

4. User-defined preferred PLMN,

5. Other PLMNs with received signal level above a predetermined strength in random order, and

6. All other PLMNs in order of descending signal strength.

9. A Subscriber Identity Module according to Claim 8 in which the PLMN is stored in the "Operator List" reserved in a fixed but implementation-dependent memory location in the Subscriber Identity Module.

10. A Subscriber Identity Module according to Claim 8 or 9, in which the "PLMN Selector" data comprises PLMNs listed in the "Operator List" copied to the "PLMN Selector", the "Operator List" taking precedence over user-defined preferred PLMNs which are appended at the end of the "Operator List" in the "PLMN Selector".

11. A Subscriber Identity Module, for a mobile telephone, pre-programmed to, in use, perform a network update procedure wherein Public Land Mobile Networks ("PLMNs") contained in a "PLMN Selector" data field based on an "Operator List" have preference over other User-defined or Operator-defined preferred PLMNs.